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LONG-DISTANCE PROPAGATION MEASUREMENTS AT UHF:

Comparisons between results using BBC and CCIR prediction methods

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THE BRITISH BROADCASTING CORPORATION

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Summary

This Report gathers together available data on measurements over long distance propagation paths in the UHF Broadcast Band made by the BBC and other UK organizations, and uses them to test the accuracy of both BBC and CCIR field strength prediction methods. The former makes use of a terrain database, and the latter, as contained in CCIR Recommendation 370 and Report 239, a simple statistical approach. As to be expected, the accuracy of both methods is greater for oversea paths than overland. In the latter case the standard deviations are large for both methods. In some cases the discrepancy can be accounted for by local features near the receiving location but in others they cannot.

Comparisons between measurements obtained for long oversea paths over different but extensive periods of time imply that uncertainty about temporal statistics may set the limit to practicable improvements in prediction accuracy.

Issued under the Authority of

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1. INTRODUCTION

With ever increasing use of the UHF spectrum the need for accurate field strength prediction methods also increases in importance. Whilst much work has been carried out in recent years on prediction methods for evaluating coverage areas of broadcast and mobile services, less attention appears to have been paid to gathering data over longer propagation paths relevant to the calculation of interference under abnormal propagation conditions.

A very considerable amount of field strength measurement data is available, against which to test prediction methods, for path lengths corresponding to transmitter coverage areas, i.e. up to about 100 km. Such measurements will usually have been obtained in the course of a coverage survey, and on the assumption that signal levels will not vary appreciably with time. They are thus considered to represent '50% time' values.

For planning purposes there is, however, a need to be able to predict field strengths occurring under abnormal propagation conditions. Measurement data for this purpose can only be obtained by means of long-term field strength recordings. Over the last 40 years various organizations within the UK, including the BBC, have carried out a series of such measurement campaigns within the VHF and UHF Bands (currently now extended to SHF under COST* projects). Nevertheless the amount of available data is still very limited and it is hoped that an international databank can be developed under the aegis of CCIR IWP 5/5. If and when developed, such an extended data bank of propagation statistics should be extremely valuable in the development of improved prediction methods.

This Report therefore has two aims:

i) To summarize in a convenient form as much as possible of the available measurement data relating to UHF measurements having receiving terminals in the UK.

ii) To compare the accuracy of the prediction method developed a number of years ago by the BBC[1-5] with the latest version of the internationally agreed statistical method contained in CCIR Rec. 370 and associated Report 239[6]. This comparison is required as part of an on-going process of improving prediction methods.

2. PROPAGATION PATHS

CCIR Rec. 370 contains different sets of propagation curves for field strengths exceeded for 1%, 5%, 10%, and 50% of the time for overland paths and for paths over 'cold' and 'warm' seas, (the warm sea curves not being relevant to propagation paths bordering the UK). Interpolation methods are given in Report 239 for the case of 'mixed' land/sea paths. That used in comparisons in this Report is termed Method A.

It was therefore necessary first to classify the measurement paths into the categories of Overland, Oversea, and Mixed. There being very few paths for which both transmitting and receiving sites were exactly at the coast, for the purpose of this classification paths were considered to be 'oversea' provided that more than 90% of the path was oversea and that the sea was visible from both terminals.

In practice nearly all the measurements considered here were carried out between 1955 and 1970 by either the BBC, the GPO, or the DSIR. Over a number of the paths investigated by the BBC, consecutive measurements were made at a frequency in Band IV and in Band V. As Rec. 370 makes no differentiation between these Bands (and the frequency dependence in the BBC method is small) the measurement results were averaged using a weighting factor derived from the durations of the two series of measurements. The question of frequency dependence is discussed in a later section.

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* Cooperation On Science and Technology

In some of the BBC measurement programmes simultaneous recordings were made at two receiving antenna heights, the lower of which was always at about 10 m above ground. For the purpose of the comparisons in this Report only these lower height measurements have been taken into account.

In total the results of measurements over some 78 propagation paths are examined here, sub-divided as follows:

Type of Path	Number	Path Lengths (km)	
		Min	Max
Overland	37	50	470
Mixed land/sea	28	117	672
Oversea	13	96	954

3. TRANSMITTING AND RECEIVING TERMINALS

Details of the transmitting and receiving terminals are given in Tables 1 and 2 respectively.

4. RESULTS OF MEASUREMENTS

These are tabulated in Table 3 (Overland paths), Table 4 (Oversea paths) and Table 5 (Mixed paths). For this purpose oversea paths are arbitrarily defined as paths which are greater than 90% oversea with both terminals within line of sight of the coast.

In Tables 3 - 5 the measured values of field strengths exceeded for 1%, 5%, 10%, and 50% of the recording period are tabulated for each path. All values are normalized to a radiated e.r.p. of 1 kW.

Also indicated in Tables 3 - 5 are the following parameters used in the CCIR predictions:

i) The effective transmitting antenna height (h_1) as defined in Rec. 370.

ii) The receiving terrain clearance angle and resulting correction in dB, as defined in Section 4.2 of CCIR Report 239-6.

iii) The terrain irregularity factor (Δh) as defined in Rec. 370. Note however that the same sign convention is adopted here as for (ii) namely a positive correction implying that the field strength predicted from the curves has to be increased to relate to the specific location.

5. SITE VARIATION FACTOR (s.v.f.)

Receiving locations chosen for long term propagation tests are nearly always determined by practical considerations and will not necessarily be representative of receiving locations in the area. As part of a measurement campaign it was therefore normal practice to derive a 'site variation factor' to correct the measured field strength values to those to be expected at a 'representative' location. Such s.v.fs may have been based either on measurements or predictions. In cases where such values were provided in the original Reports these are reproduced in Tables 3 - 5 for comparison with the correction factor derived from the receiving terrain clearance angle as discussed in 4(ii) above, using the same sign convention.

In the case of oversea paths, and mixed land/sea paths having a receiving location on the coast, an additional correction has to be applied in order to compare measurements to predictions using CCIR Rec. 370. This is discussed in Section 6.2.

Table 1: Details of transmitting sites

Name	Lat.	Long.	Site Height amsl (m)	Antenna Height agl (m)	Freq. (MHz)	**Note**
Crystal Palace	51N25	0W04	110	194	580	
				210	660	**1**
Holme Moss	53N32	1W51	524	181	565	
Pontop Pike	54N52	1W46	305	122	774	**2**
				125	560	**3**
Sutton Coldfield	52N36	1W50	169	181	500	**4**
				183	600	**5**
				181	630	**6**
Caen	48N58	0W37	345	200	508	
Le Havre	49N30	0 E 11	84	105	652	
Cuxhaven	53N50	8 E 40	27	125	500	
Lopik	52N01	5 E 03	0	160	628	
Caradon Hill	49N31	4W26	367	233	533	
Rowridge	50N41	1W22	137	142	510	
Portland	50N40	4W01	148	8	670	
Stockland Hill	50N48	3W06	229	233	757	
Scheveningen	52N06	4 E 16	13	47	560	**7**
					774	**8**
Dusseldorf	51N07	7 E 06	235	210	540	
Dortmund	51N31	7 E 27	100	200	525	
					540	
Cuxhaven	53N50	8 E 39	27	99	508	
Huisduinen	52N57	4 E 44	17	8	950	
Belowda	50N26	4W51	227	9		

Note 1: Received at Oxford and Great Baddow only.
2: Received at Beddingham, Dishforth, Slough, Moorside Edge, Dorket Head, Mursley and Kingswood.
3: Received at Beddingham, Dorket Head, Ottringham and Mursley.
4: Received at Kingswood, Green Hailey, Beddingham and Mursley.
5: Received at Green Hailey only.
6: Received at Brookmans Park and Hatfield.
7: Oversea paths: received at Feltwell, Morborne, Pontop Pike, Skeffington and Tacolneston.
8: Oversea paths: received at Bawdsey, Manningtree, Brookmans Park and Great Baddow.

Table 2: Details of receiving sites

Name	Lat.	Long.	NGR	Site Height amsl (m)	Antenna Height agl (m)
Aldeburgh	52N09	1 E 36	TM 464562	3	12
Alderney	49N43	2W11		61	8
Banbury	52N03	1W19	SP 464389	122	9
Bawdsey	52N00	1 E 25	TM 341383	5	13
Bearley	52N14	1W43	SP 192603	107	9
Beddingham	50N50	0 E 04	TQ 457059	183	9
Bridge of Don	57N11	2W05	NJ 950095	9	9
Brookmans Park	51N44	0 E 11	TL 259049	128	12
Castleton	51N33	3W04	ST 259846	110	9
Caversham	51N29	0W57	SU 725763	82	12
Christchurch	50N44	1W43	SZ 198929	18	4
Darlington	54N29	1W37	NZ 246096	70	9
Dishforth	54N09	1W25	SE 377724	34	12
Dorket Head	53N01	1W06	SK 597472	140	9
East Harptree	51N17	2W39	ST 550535	293	8
Feltwell	52N29	0 E 31	TL 710900	15	9
Flamborough Head	54N08	0W05	TA 247719	46	9
Great Baddow	51N42	0 E 30	TL 729037	46	12
Green Hailey	51N43	0W48	SP 829034	241	9
Halwell	50N21	3W43	SX 775517	213	8
Happisburgh	52N50	1 E 32	TG 376317	15	9
Hatfield	51N45	0W14	TL 215075	71	10
Heathfield	50N59	0 E 51	TQ 566220	157	62
Kingswood	51N17	0W13	TQ 248560	167	9
Lerwick	60N08	1W11	HU 456394	91	9
Manningtree	51N55	1 E 05	TM 123295	31	10
Moorside Edge	53N38	1W54	SE 071153	338	12
Morborne Hill	52N30	0W20	TL 126913	56	9
Mursley	51N57	0W48	SP 815293	158	9
Ottringham	53N42	0W04	TA 276241	9	9
Oxford	51N45	1W15	SP 513058	55	14
Peatling Magna	52N30	1W07	SP 600910	110	9
Pontop Pike	54N52	1W46	NZ 148526	305	9
Shrivenham	51N35	1W39	SU 241894	98	9
Slough	51N29	0W34	SU 996776	18	14
Skeffington	52N37	0W54	SK 739035	210	9
Stoke Fleming	50N19	3W36	SX 858483	98	9
Stow-on-the-Wold	51N56	1W44	SP 189251	232	9
Sunrising Hill	52N07	1W30	SP 345468	98	9
Tacolneston	52N31	1 E 08	TM 131958	64	9
Torteval	49N30	2W40		71	9
West Beckham	52N54	1 E 11	TG 141389	91	17
Whitburn	54N56	1W22	NZ 405609	11	10
Wickhambrook	52N11	0 E 33	TL 743578	122	12
Widley	51N50	1W36	SP 272142	177	9

Table 3: UHF data for overland paths

Path No.	Transmitter	Receiving Location	Receiving Location Correction			Path Length (km)	Eff. Ht. (m)	Δh		Measured field strengths for specified time % (db (uV/m) for 1 kW e.r.p.)				Duration (months)
			s.v.f.	clearance angle	corr. (dB)			(m)	Corr. (dB)	1%	5%	10%	50%	
1	Crystal Palace	Bawdsey	−17	−0.04	0	120	280	65	−2	21	7.5	2		29
2	Crystal Palace	Caversham	−16.5	0.22	6.5	61	280	35	2.5	41.5	41	40.5	39.5	29
3	Crystal Palace	Manningtree		0.07	3.5	98	280	75	−3	53	42	38.5	32.5	29
4	Crystal Palace	Morborne Hill	−10.5	0.07	3	122	290	70	−2.5	31	20	15.5	7.5	29
5	Crystal Palace	Mursley		0.23	7	78	285	105	−7	50.5	47.5	47	45	29
6	Crystal Palace	Tacolneston		0.08	5	147	290	60	−1	38	23.5	17	5	29
7	Crystal Palace	Sunrising Hill	+7	−2.55	−16	125	290	130	−8	8	2	−1*	−4.5*	7
8	Crystal Palace	East Harptree		0.82	21.5	180	285	80	−2	33.5	19	16	11	2
9	Crystal Palace	Bearley		0.13	4	145	290	110	−6	29	18	13	2.5	6
10	Crystal Palace	Aldeburgh	+6	0	1	141	280	75	−2.5	25	20	16.5	8	3
11	Crystal Palace	Banbury	+11	−0.08	0	111	295	115	−7.5	31.5	27.5	26	22	8
12	Crystal Palace	Oxford		−0.04	−5	90	290	85	−4.5	46.5	45.5	45	41.5	4
13	Crystal Palace	Great Baddow		−0.14	−1	51	290	85	−5	47	43.5	42	40	4
14	Crystal Palace	Shrivenham		−0.07	0	111	280	21	5	10	5	2	−6	12
15	Crystal Palace	Darlington		0	2	356	290	75	−1.5	−10				6
16	Crystal Palace	Stow-on-Wold		0.32	8.5	127	295	85	−4.5	22.5	17	15	11	12
17	Crystal Palace	Peatling Magna		−0.66	−7.6	141	295	82	−3.5	5.5	−2.5	−6	−16	4
18	Crystal Palace	Castleton		0.46	12	208	280	52	0	14	9	6	−3.5	6
19	Holme Moss	Kingswood	−5.5	0.04	2	275	300	240	−8	14	2*	−5*		17
20	Holme Moss	Mursley	7.5	0.33	8.5	189	270	295	−11	47	31.5	24.5	11	17
21	Holme Moss	Beddingham	13.5	0.58	15.5	328	295	245	−8	18.5	−4*	−6*		14
22	Pontop Pike	Beddingham	13.5	0.54	14	465	255	135	−4.5	6	−7			41
23	Pontop Pike	Dishforth	10	0.1	3.5	83	255	135	−9	56.5	52	50	46.5	17
24	Pontop Pike	Slough		−0.32	−3.5	384	250	135	−4.5	−18				18
25	Pontop Pike	Moorside Edge	1	−0.46	−5.5	138	210	170	−9.5	27	18	15	4.5*	23
26	Pontop Pike	Dorket Head	1.5	−0.1	−0.5	210	250	135	−4.5	15	10	7		41
27	Pontop Pike	Ottringham	2.5	0.04	2	171	255	120	−5	31	19	14.5	3.5	18
28	Pontop Pike	Mursley	10	0.35	10	330	255	135	−4.5	18	7	3		41
29	Pontop Pike	Kingswood	−5.5	0.12	4	411	255	130	−4.5	2				35
30	Sutton Coldfield	Kingswood	−5.5	0.13	4	184	250	55	−0.5	17	3			17
31	Sutton Coldfield	Green Hailey		0.48	12.5	120	250	55	−0.5	56	50	47	43	17
32	Sutton Coldfield	Beddingham	13.5	0.6	16	236	255	60	−0.5	23	12.5	9		10
33	Sutton Coldfield	Mursley	13	0.3	8	100	255	80	−4	56.5	51	49.5	45	13
34	Sutton Coldfield	Brookmans Park		0.12	4	149	260	60	−1	29	17.5	13.5	5	13
35	Sutton Coldfield	Hatfield		−0.33	−3.5	144	260	65	−1.5	19.5	11	9	4	13
36	Belowda	Widley		0.24	7	275	145	190	−7	14	6.5	3	−7	24
37	Belowda	West Beckham		0.14	4.5	500	145	190	−6.5	−24				15

* Extrapolated values

Table 4: UHF data for oversea paths

Path No.	Transmitter	Receiving Location	Receiving Location Correction			Path Length (km)	Eff. Ht. (m)	Measured field strengths for specified time % (db (uV/m) for 1 kW e.r.p.)				Duration (months)
			s.v.f.	clearance angle	corr. (dB)			1%	5%	10%	50%	
38	Le Havre	Christchurch	+7	+0.15	+4.5	193	140	58	45	34	13	24
39	Cuxhaven	Whitburn		+0.13	+4	660	125	29	−5			33
40	Rowridge	Torteval		+0.34	+9	167	270	68	57	49	19.5	18
41	Rowridge	Alderney		+0.33	+9	121	270	69.5	64	59.5	43	18
42	Portland	Alderney		+0.38	+9	96	155	71	66	62.5	49.5	10
43	Scheveningen	Bawdsey		+0.12	+3.5	196	60	58.5	42.5	28	3.5	26
44	Scheveningen	Manningtree	+6	+0.18	+4.5	218	60	51.5	36.5	24	4*	60
45	Scheveningen	Happisburgh	+6	+0.14	+4.5	198	60	64	45.5	30.5	6	60
46	Scheveningen	Flamborough Head	+11*	+0.25	+7	365	60	53	24	8		60
47	Scheveningen	Newton-by-Sea	+7*	+0.16	+5	543	60	35.5	2.5	−6		60
48	Scheveningen	Bridge-of-Don	+4*	+0.12	+4	696	60	19				60
49	Scheveningen	Lerwick	+14*	+0.41	+11	954	60	10.5				60
50	Huisduinen	West Beckham		+0.2	+6	222	25	55	32	21	−5	16

NOTE:

* Values in site variation factor (s.v.f.) column were those given in original reports on measurements and were derived from the formula:

s.v.f. $= k\,h^{2/3}$

where h = receiving antenna height above sea level (m).

Table 5: UHF data for mixed overland/oversea paths

Path No.	Transmitter	Receiving Location	Receiving Location Correction			Path Length (km)	Eff. Ht. (m)	% Sea	Δh		Measured field strengths for specified time % (db (uV/m) for 1 kW e.r.p.)				Duration (months)
			s.v.f.	clearance angle	corr. (dB)				(m)	Corr. (dB)	1%	5%	10%	50%	
51*	Caen	Christchurch	+7	+0.13	+4.5	212	380	77	140	−4.5	50.5	41	32.5	6.5	
52*	Lopik	Aldeburgh	+10	+0.11	+3.5	237	170	76	10	+5	47	27	18	3	12
53	Lopik	Wickhambrook		+0.15	+4.0	308	160	60	10	+5	19	7	1		7
54	Dusseldorf	Wickhambrook		+0.14	+4.5	468	210	36	65	−1	7	−10	−17	−30	38
55	Dusseldorf	Banbury		−0.17	−1.5	591	210	29	65	−1	−20				30
56*	Dusseldorf	Aldeburgh	+10	+0.11	+3.5	396	210	45	65	−1	20.5	1	−6	−19	38
57*	Dortmund	Aldeburgh		+0.11	+3.5	408	200	44	25	+2.5	14**	−1	−5	−19	16
58	Dortmund	Wickhambrook		+0.13	+4	480	200	35	25	+2.5	18	−10	−17	−28	5
59	Dortmund	Slough		+0.05	+1.5	554	200	38	25	+2.5	−21				7
60	Cuxhaven	Slough		−0.09	0	672	100	42	10	+5	−12				7
61	Crystal Palace	Halwell	0	+0.69	+18	283	280	25	40	−1	18	5	0	−11	9
62*	Crystal Palace	St. Fleming		−0.47	−5.5	276	280	26	40	−1	3	−3	−6	−21	8
63	Caen	Kingswood	−4	−0.5	−5.5	259	375	65	133	−4.5	19	8.5	3		24
64	Caen	Mursley	+13	+0.33	+9	332	375	48	135	−4.5	15	6	3		24
65	Caen	Caversham	+10	+0.17	+5	281	380	56	140	−5	22.5	13	9.5		24
66	Le Havre	Caversham	+10	+0.17	+5	234	135	61			19.5	13			24
67	Le Havre	Mursley	+13	+0.25	+6.5	282	125	50			18	13.5			24
68	Le Havre	Kingswood	−4	−0.6	−7	202	110	66			17	8	4		24
69	Rowridge	Heathfield		N.A.		117	N.A.	14	N.A.	N.A.	55	46	40.5	34.5	1
70*	Caradon Hill	Torteval		+0.33	+10	174	495	85	80	−1.5	68	61	55	27	25
71*	Stockland Hill	Alderney		+0.33	+9	137	410	88			73.5	68.5	64.5	46.5	4
72	Scheveningen	Brookmans Park	+6.5	+0.3	+8	307	60	67			13				13
73	Scheveningen	Great Baddow	−0.5	−0.4	−5	262	60	87			32.5	19	8.5		26
74	Scheveningen	Feltwell	0	0	+1	258	60	68			22	9.5	5.5		15
75	Scheveningen	Morborne Hill	+10	+0.3	+8	316	60	56			28.5	10.5	4		15
76	Scheveningen	Pontop Pike		+0.6	+16	505	60	79			12				14
77	Scheveningen	Skeffington	+25	+0.25	+7.5	356	60	50			30.5	10.5	3		15
78	Scheveningen	Tacolneston	−9	+0.23	+6.5	217	60	80			35.5	22.5	11		15

Paths 66 - 68 and 71 - 78: Transmitter either at coast or sufficiently near to the coast for the concept of Δh to be not applicable.
* Coastal receiving site
** Average of individual values differing by 14.5 dB for recordings over two successive years

6. COMPARISON BETWEEN MEASUREMENTS AND PREDICTIONS BASED ON CCIR REC. 370

Tables 6 - 8 indicate, for overland, oversea, and mixed land/sea paths respectively, the ratios of predictions using Rec. 370 to measurements. Where relevant, the CCIR predictions are made both with, and without, the Δh correction. This correction is considered not to be relevant in the case of oversea paths, or to mixed paths for which the transmitter is within, say, 20 km of the coast.

Estimated Δh corrections have been rounded to the nearest 0.5 dB. As Rec. 370 contains no UHF propagation curves for the 5% time overland condition these have been interpolated from the 1% and 10% values on the basis of a log-normal distribution.

6.1 Overland paths

The comparison between predictions and measurements is indicated in Table 6. The predictions include the receiving terrain clearance angle correction rather than the s.v.f. This was done to enable the measurements to be compared to a generalised prediction rather than to one taking account of special factors based on individual measurements.

A feature of Table 6 is that application of the Δh correction increases the standard deviations for all time percentages, although reducing the mean error for all but the 1% time. In effect the fact that the Δh correction makes the mean error values some 3 - 4 dB less positive is merely an indication of the fact that the reference Δh value of 50 m represents a substantially flatter terrain than that typical of the propagation paths investigated.

Median values of the predicted : measured (P:M) ratio are indicated in addition to the mean values. In most cases the two values differ by less than 1 dB, although in the case of 5% time without Δh the discrepancy is over 4 dB.

6.2 Oversea paths

The comparisons between predictions and measurements are indicated in Table 7. It may be seen that the mean P:M ratio varies from −2.8 dB for 1% time to −6.5 dB for 50% time. However although the wording of the relevant Section (2.1.2) of Report 239-6 is ambiguous, it is generally recognized that the UHF curves of CCIR Rec. 370 are intended to be representative of those expected in coastal towns and some 7 dB lower than expected at typical rural coastal locations. Hence as virtually all the receiving locations used could be considered as rural it might be expected that mean differences of some −7 dB would occur. On this basis the mean errors for time percentage other than 1% are close to expectation and 1% time field strengths are somewhat higher than predicted.

The standard deviation is significantly lower than for the overland paths. This is not particularly surprising because:

i) Path profile variability is obviously much less, and

ii) The measurements against which the comparisons are made are mainly those used in the original production of the CCIR curves.

6.3 Mixed land/sea paths

Comparisons between predictions and measurements are indicated in Table 8. In this case the results are separated into those having coastal and inland receiving locations, in each case both with, and without the Δh correction. The comparisons without this correction indicate a mean error of about −5 dB for all time percentages at coastal locations and about +5 dB at inland locations. The negative values at coastal sites are consistent with the correction required for rural locations discussed in Section 6.2 above, and in this case application of the Δh correction, although superficially reducing the mean errors, actually produces a result which is less consistent with what the curves claim to represent under this condition. Application of the Δh correction does however reduce the standard deviation, except for 1% time.

For inland receiving locations it would appear that the prediction tends to overestimate field strengths, with application of the Δh correction tending to increase the error without reducing the standard deviation.

Table 6: UHF overland paths
Comparison between measurements and predictions by the CCIR method including receiving terrain clearance angle correction.

Path No.	Ratio Prediction : Measurement (dB) for specified time percentage							
	CCIR method without Δ*h* correction				CCIR method with Δ*h* correction			
	1%	5%	10%	50%	1%	5%	10%	50%
1	8	17	17.5		7	15	17.5	
2	10.5	7.5	6.5	5.5	13	10.5	9	8
3	7	13	15	18	4	10	12	15
4	1.5	7	8.5	10.5	−2	4.5	6	7.5
5	−3	−4	−6	−7	−10	−11	−13	−14
6	−7.5	1	4	9	−8.5	−0.5	3	7.5
7	5.5	5.5	5.5	3	−2.5	−2	−2	−5
8	8	16.5	16	13.5	6	14	14	11.5
9	1	6	7.5	11	−5	0	2	5
10	3	2	2.5	3	0.5	−0.5	0	0.5
11	0.5	−0.5	−2	−3.5	−7	−8	−9.5	−11
12	−14.5	−18	−19	−21	−19	−22.5	−24.5	−25.5
13	2.5	3.5	4.5	4	−3	−1.5	−1	−0.5
14	21.5	21.5	21.5	24	27	26.5	27	29
15	9				9.5			
16	15	15	14	11.5	10.5	10.5	9.5	7
17	13.5	15.5	15.5	18.5	10	10	12.5	17
18	15	14.5	13.5	14.5	15	14.5	13.5	14.5
19	−3.5	2.5	6.5		−11.5	−5.5	−1.5	
20	−19.5	−11	−7	−1.5	−31	−22	−18	−12
21	−1	15.5	14		−9.5	7.6	6	
22	−2.5	3.5			−7	−1		
23	−15	−15	−15.5	−16	−24	−24	−24.5	−25
24	10.5				6.5			
25	−7.5	−4	−4	−1	−16	−13.5	−13.5	−10
26	−0.5	−1.5	−1.5		−5	−6	−8	
27	−8.5	−2.5	−1	2	−14	−8	−6.5	−2
28	−6.5	−1.5	−1		−11	−7	−5.5	
29	−4				−8.5			
30	5.5	13.5	16.5		5.5	13.5	16	
31	−14.5	−14	−26.5	−24	−15	−14.5	−25.5	−23.5
32	5	9.5	10		4.5	9	9.5	
33	−13	−11	−12	−11.5	−13	−11.5	−12.5	−12
34	−1	4.5	5.5	6.5	−2	3.5	4.5	5
35	−15	−14	−15.5	−16	−18.5	−18	−19	−19.5
36	−0.5	1	1.5	2	−6.5	−5	−5	−4
37	13.5				7.5			
Mean values (dB)	0.6	3.5	3.5	2.7	−2.7	−0.6	−0.4	−1.0
Std. devs. (dB)	9.7	10.2	11.4	12.3	12.1	12.2	13.3	14.1
Median values (dB)	−0.5	−1	5	3	−5	−1	−0.5	−0.5

Standard deviations are greater for inland sites than for coastal sites. This is perhaps to be expected if one of the greatest factors in determining field strengths is the nature of the terrain near the receiving terminal.

7. COMPARISON BETWEEN MEASUREMENTS AND PREDICTIONS USING THE BBC METHOD

The current BBC method of UHF field strength prediction is described in various references[1-5]. It should be noted that the various parameters used in the method (especially for 1% and 5% time conditions) were optimized using most of the measurements detailed in this Report. No predictions are made for the 10% time condition in the BBC method because this is not considered of particular importance in planning. As the method provides a prediction representative of a specific receiving location (or at least of the 0.5 km square within which the receiving location is sited) no receiving location factor has to be applied.

The calculation contains a 'clutter loss' derived from the statistical probability of occupancy by buildings or trees of the first Fresnel zone within 0.2 km of the receiving location. This particular algorithm was developed with a view to possible use with some form of land occupancy data bank, but as currently implemented the calculations all assume a clutter height distribution considered to be representative of a suburban area, i.e., it is to be expected that calculated losses will be too high in the rural areas considered here.

The calculated clutter loss is independent of the time-percentage and depends solely on the slope of the foreground in the direction of the transmitter. Manual correction is required to remove the loss where not relevant.

In optimizing the parameters used in the prediction method, specific values of clutter loss were assumed rather arbitrarily from inspection of the receiving sites. However it is important to recognize that this correction is not equivalent to the s.v.f. correction, which also takes account of topographical variations.

Table 7: UHF oversea paths

Comparison between measurements and predictions by the CCIR method including receiving terrain clearance angle correction.

Path No.	Ratio Prediction : Measurement (dB) for specified time percentage			
	1%	5%	10%	50%
38	−0.5	−6.5	−8	−7.5
39	−11	−4		
40	−3.5	−7.5	−7.5	−3
41	−1	−7	−8.5	−15
42	0	−6	−8	−15.5
43	1	−5.5	−3	−2.5
44	0	−5	−3	−5.5
45	0.5	−4	−1	0
46	−8.5	−5.5	−3.5	
47	−6	−1.5	−9.5	
48	0			
49	5			
50	−2.5	−1.5	−2.5	2
Mean values (dB)	−2.0	−4.9	−5.5	−5.3
Std. devs. (dB)	4.3	2.0	3.1	7.1

Table 8: UHF mixed land/sea paths
Comparison between measurements and predictions by the CCIR method with and without including receiving terrain clearance angle correction.

Path No.	Ratio Prediction : Measurement (dB) for specified time percentage							
	CCIR method without Δh correction				CCIR method with Δh correction			
	1%	5%	10%	50%	1%	5%	10%	50%
51*	−4	−7.5	−5	−0.5	−6	−9	−6	−1.5
52*	−6.5	−1.5	−0.5	−5	−5	0.5	1.5	−4
53	6.5	6	5.5		9.5	8.5	7.5	
54	−4	2.5	4	3	−4.5	1.5	3.5	2.5
55	5				4			
56*	−8	−0.5	−1.5	−1.5	−8.5	−1	−1.5	−2
57*	−4.5	−0.5	−2	−2	−2	0.5	−0.5	−1.5
58	−16	1	2.5	−0.5	−14	3	4.5	1.5
59	14.5				16.5			
60	−6				−2.5			
61	14	19	20	18.5	15	20	21	19.5
62*	6.5	4	3.5	5.5	7.5	5	4.5	6.5
63	6	5	5		4	2.5	3	
64	10	8.5	7		6.5	4	3.5	
65	7.5	6	4.5		5	3.5	2	
66	16	10						
67	8.5	2						
68	11	7	4.5					
69**								
70*	−10	−14	−13.5	−8.5				
71*	−8.5	−14	−15.5	−21.5				
72	18							
73	1	−4.5	−4					
74	8	6	2.5					
75	−2.5	2	1.5					
76	15.5							
77	−12	−4.5	−3					
78	11	7.5	10.5					
Coastal receiving sites								
Means (dB)	−4.9	−4.9	−4.9	−4.8	−2.8	−0.8	−0.4	0.2
Std devs. (dB)	5.5	7.1	7.0	8.5	6.2	5.1	3.9	4.0
Inland receiving sites								
Means (dB)	5.6	4.9	4.7	7†	4.0	6.1	6.4	7.8†
Std devs. (dB)	9.5	5.8	6.0	10.4†	9.2	6.5	6.7	10.1†
Overall								
Means (dB)	2.9	1.8	1.3	−1.3				
Std devs. (dB)	9.2	7.6	7.8	10.2				

* Coastal receiving site

** Not relevant to this analysis: high receiving antenna height

† Based on only three samples.

Table 9: UHF overland paths
Comparison between measurements and predictions* by the BBC method.

Path No.	Ratio Prediction : Measurement (dB) for specified time percentage			Predicted clutter loss
	1%	5%	50%	(dB)
1	13.5	21.5		14
2	26	26.5	22	3.5
3	12.5	17	20.5	14.5
4	5.5	12	12.5	11.5
5	−4	−5	−6.5	9.5
6	−4.5	−1.5	6	11.5
7	9	2.5	6.5	9.5
8	1	−4	−5	13
9	−9.5	−11	−4.5	13.5
10	12	0.5	−3.5	13.5
11	4	0.5	−2	7.5
12	−12	−14	−12	8
13	−4.5	−6.5	−8	11.5
14	24.5	23.5	28	10
15	12			10
16	31.5	29	27.5	1
17	8.5	3	10.5	14
18	6	−1	1.5	8
19	11	−2	4.5	11.5
20	0.5	−1.5	2.5	4
21	1.5	−5		4
22	−5.5	−6.5		6
23	−12.5	−10.5	−5	15
24	6			14
25	−9	−12	−4.5	11
26	11.5	−6		9.5
27	−8	−0.5	−3	13
28	−5	−8		4
29	−3.5			12.5
30	12	17.5		11.5
31	−6	−7.5	−30	11.5
32	6	−1.5		2.5
33	−3.5	−6.5	−6.5	3
34	3.5	6.5	2	8.5
35	1	−8	−9.5	14.5
36	−6.5	−9	−3	4
37	13			8
Mean values (dB)	3.7	1.0	1.6	9.5
Std devs. (dB)	10.6	11.7	12.9	
Median values (dB)	5.5	−2.0	−2.0	

* Predictions in Tables 9-11 include the clutter loss specified.

In view of the above it is somewhat difficult to carry out a comparison between measurement and BBC prediction of the type already made for the CCIR method. In the following sub-sections the ratios of predictions with clutter loss to measurement are tabulated together with the value of this clutter loss (rounded to the nearest 0.5 dB). In Section 8, results over individual paths are examined and in these cases the predicted values quoted include this 'statistical' clutter loss.

7.1 Overland paths

Comparisons between measurements and predictions are indicated in Table 9. It may be seen that the mean error is somewhat greater than for the CCIR method (without the Δh correction) at 1% time but less for 5% and 50% times. Standard deviations are slightly greater than for the CCIR method (although less than for this method with the Δh correction applied). There is a significant difference between the mean and median values indicating a somewhat asymmetric distribution.

N.B. The standard deviations obtained after removing clutter losses from each prediction are within 0.5 dB of those tabulated although, of course, the mean errors are increased by the mean value of clutter loss.

7.2 Oversea paths

Comparisons between measurements and predictions are indicated in Table 10. There would seem to be a definite tendency, especially for 50% time, for the prediction method to underestimate field strengths. Standard deviations are comparable with those for the CCIR method (greater for 1% time but less for 50% time).

7.3 Mixed land/sea paths

Comparisons between measurements and predictions are indicated in Table 11. In this case any comparisons between these results and those obtained from the CCIR method (Table 8) is difficult to make because of the need to separate paths into those with coastal and inland receiving locations in the CCIR method. It may however be seen that the BBC method gives a relatively small mean error.

Table 10: UHF oversea paths
Comparison between measurements and predictions by the BBC method.

Path No.	Ratio Prediction : Measurement (dB) for specified time percentage			Predicted clutter loss
	1%	5%	50%	(dB)
38	−2	2.5	−9	5.5
39	−10.5	−6.5		10.0
40	−8	0	−1.5	2.5
41	−9	−0.5	−0.5	5.0
42	−8.5	−3.5	−7.5	4.5
43	−8	−1	−9	10.5
44	−6	−3.5	−16	14.5
45*	−14.5	−6	−12.5	11.0
46*	0	−2.5		2.5
47*	7	−4.5		9.0
48*	−2.5			9.0
49*	−0.5			0
50*	−8	−1	−8	12.5
Mean values (dB)	−5.4	−2.4	−9.1	7.4
Std devs. (dB)	5.6	2.7	4.2	

* Duration-weighted average of measurements on two frequencies (560 and 774 MHz).

Table 11: UHF mixed land/sea path
Comparison between measurements and predictions* by the BBC method.

Path No.	Ratio Prediction : Measurement (dB) for specified time percentage			Predicted clutter loss
	1%	5%	50%	(dB)
51	4	2	−0.5	5.5
52	2	6.5	−12.5	10.5
53	5	6.5		8.5
54	5	2	5	7.5
55	15.5			3.5
56	−8.5	−5	−4.5	10.5
57	−4	−6	−5.5	10.5
58	−9.5	0	1.5	8.0
59	14			13.5
60	−4.5			13.0
61	−1.5	−2.5	2	8.0
62	−6	−6.5	2.5	9.5
63	9	6.5		8.0
64	6	−3		4.5
65	9	11.5		3.5
66	5	6.5		3.5
67	−0.5	−8.5		6.0
68	8.5	6		8.0
69	5	7.5	11.5	0
70	−6.5	−4	0	0.5
71	−14	−9	−10	4.5
72	−2			11.0
73	−8	−12		0.5
74	−9	−7.5		13.5
75	−12.5	−6.6		8.0
76	9.5			3.5
77	−14.5	−10.5		8.5
78	−14.5	−5		10.0
Mean difference (dB)	0.2	−1.4	−0.9	7.2
Std devs. (dB)	8.9	6.8	6.8	

* Predictions in Tables 9-11 include the clutter loss specified.

8. EXAMINATION OF PREDICTION ACCURACY OVER INDIVIDUAL PATHS

In this section we look at comparisons between predictions and measurements over a number of specific overland paths for which there appear to be large discrepancies. The path profiles are illustrated in Figs. 1 and 2. Paths in Fig. 1 are those for which predictions overestimate field strengths, and in Fig. 2 those for which they underestimate them. Prediction : Measurement (P:M) ratios quoted are:

i) for CCIR predictions — those without the Δh correction

ii) for BBC method predictions — values including a 'statistical' clutter loss as described in paragraph 2 of Section 7. Here it is necessary to recognize that, when using results for many of these paths to optimize the parameters in the method, nearly all receiving sites were actually assumed to have some clutter loss.

8.1 Path 1 Crystal Palace to Bawdsey

For the CCIR method the P:M ratio varies from 8 dB (1% time) to 17.5 dB (10% time) whilst for the BBC method it varies from 13.5 dB to 21.5 dB. The area around the receiving site is flat and there is a single line of trees obstructing the path close to the receiving terminal. The measured s.v.f was −17 dB and the clutter loss assumed in BBC method optimization was 23 dB. Hence, assuming the s.v.f. to be largely attributable to clutter loss, the discrepancy with CCIR prediction is accounted for but the BBC prediction is still somewhat high even if increasing the clutter loss from 14 to 23 dB.

The path profile shows an appreciable section having spherical diffraction and therefore high propagation losses, i.e. low measured field strengths could be expected.

8.2 Path 2 Crystal Palace to Caversham

For the CCIR method the P:M ratio varies from 10.5 dB (1% time) to 5.5 dB (50% time) whilst for the BBC method it varies from 26.5 dB to 22 dB. Here the receiving point was shadowed by a single large tree. The s.v.f was −16.5 dB, implying a poor receiving location despite a receiving angle correction of +6 dB implying a favourable location. Hence any discrepancy resulting from the CCIR prediction is readily accounted for. Similarly for the BBC method optimization a clutter loss of 25 dB was assumed, which is consistent with the discrepancy found. The path profile indicates a clear 'line-of-sight' path.

8.3 Path 3 Crystal Palace to Manningtree

For the CCIR method the P:M ratio increases from 7 dB at 1% time to 18 dB at 50% time, whilst for the BBC method it increases from 12.5 dB to 20.5 dB. No s.v.f. measurement was made, but the area is fairly flat with no obvious obstruction to the propagation path. A clutter loss of 10 dB was assumed in the BBC method optimization, i.e. 4.5 dB less than for the actual prediction.

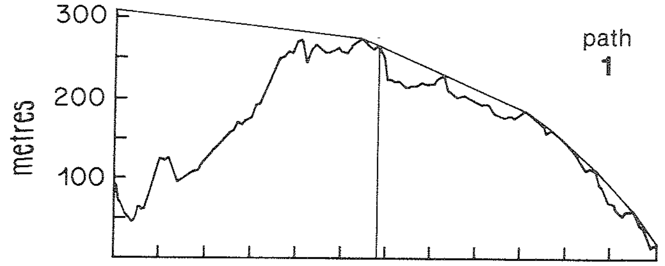
For this path there is no obvious reason why both prediction methods appear to overestimate the field strength other than that the path profile appears to show near-grazing incidence to the ground over much of the last 15 km of the path.

8.4 Path 4 Crystal Palace to Morborne Hill

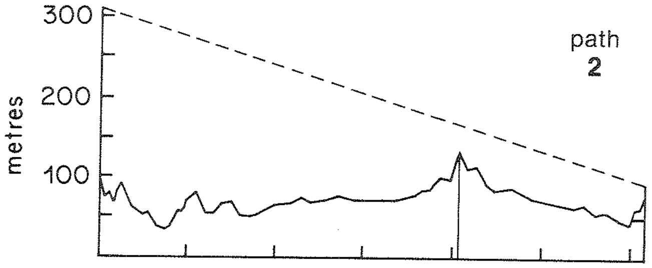
For the CCIR method the P:M ratio increases from 1.5 dB (1% time) to 10.5 dB (50% time), whilst for the BBC method it increases from 5.5 dB to 12.5 dB. The s.v.f. correction (based in this case on measurements fairly close to the receiving site) was −10.5 dB despite the site being on a modest hill, hence any overestimate by the CCIR method is easily accounted for by local factors. For the BBC method optimization a clutter loss of 15 dB was assumed leaving only a slight overestimate, as compared with the actual prediction which assumed a loss of only 11.5 dB.

8.5 Path 8 Crystal Palace to East Harptree

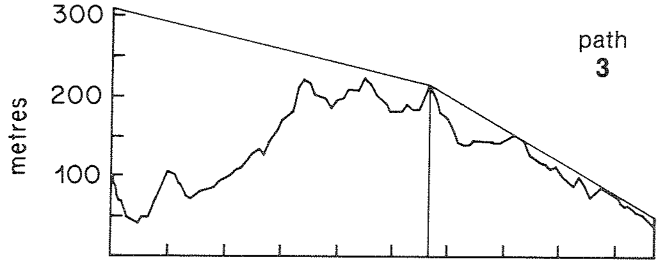
For the CCIR method the P:M ratio is in the range 8 to 16.5 dB whereas for the BBC method it is in the range 1 dB (1% time) to −5 dB (50% time). No s.v.f. was measured but for the BBC method optimization a clutter loss of 8 dB was assumed. For this particular path the BBC prediction accuracy is good due to the surprisingly high calculated clutter loss. The path is of interest in having only a single diffraction despite a path length of 180 km. It is therefore rather surprising that the CCIR method should overestimate the field strength.



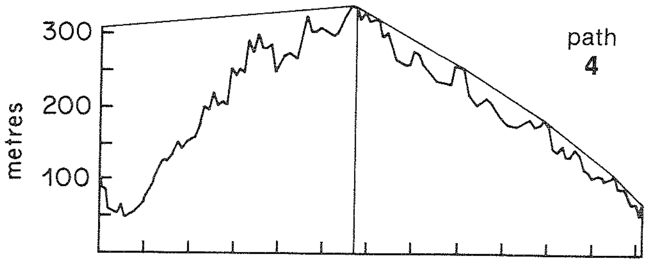
Crystal Palace to Bawdsey path length 121km



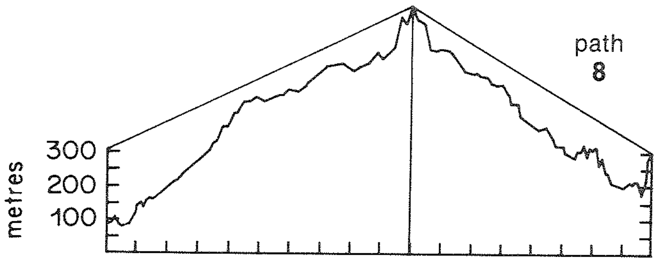
Crystal Palace to Caversham path length 62km



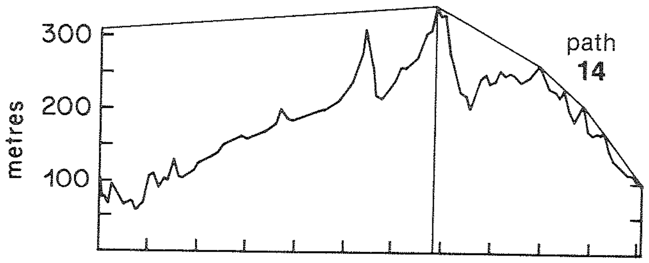
Crystal Palace to Manningtree path length 98km



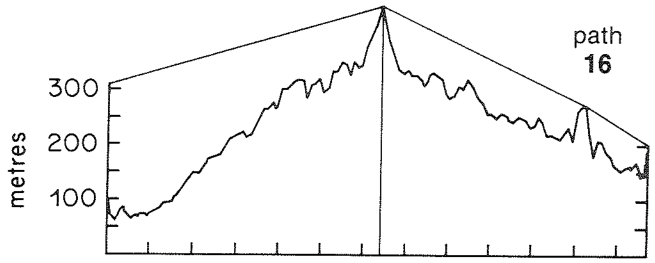
Crystal Palace to Morborne Hill path length 122km



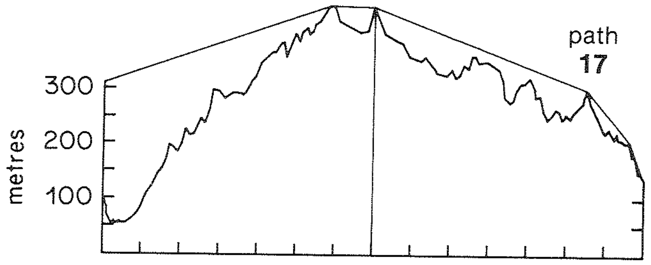
Crystal Palace to East Harptree path length 180km



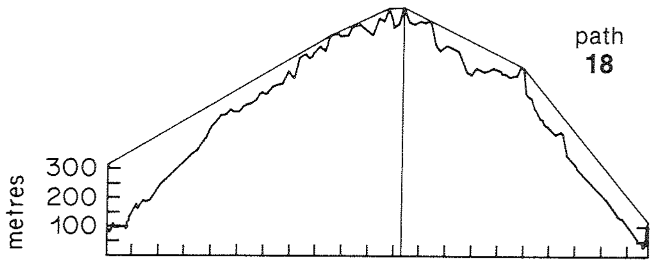
Crystal Palace to Shrivenham path length 111km



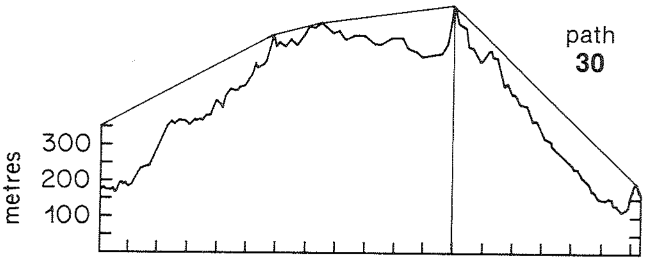
Crystal Palace to Stow on the Wold path length 127km



Crystal Palace to Peatling Magna path length 141km



Crystal Palace to Castleton path length 208km



Sutton Coldfield to Kingswood path length 184km

Fig. 1 - Paths having a high positive value of Prediction : Measurement.

8.6 Path 14 Crystal Palace to Shrivenham

For the CCIR method the P:M ratio is in the range 21.5 to 24 dB, whereas for the BBC method it is in the range 23.5 to 28 dB. Here also no s.v.f. value is available, and this particular path was not included amongst those used in optimization of the BBC method. Both methods would therefore appear to greatly overestimate the field strength for no particularly obvious reason on the basis of the path profile; possibly there was some unrecorded local obstruction.

8.7 Path 16 Crystal Palace to Stow on the Wold

For the CCIR method the P:M ratio is in the range 15 to 11.5 dB, whereas for the BBC method it is 31.5 to 27.5 dB. No s.v.f. value is available and this path (as for Path 14) was not taken into account in the optimization of the BBC method. The path profile would appear to exemplify a single diffraction with a very prominent receiving location, hence the predicted clutter loss of only 1 dB. There appears no particular reason why the measured fields should be so low.

8.8 Path 17 Crystal Palace to Peatling Magna

For the CCIR method the P:M ratio is in the range 13.5 to 18.5 dB, whereas for the BBC method it is 3 to 10.5 dB. Here again no s.v.f. value is available and the path was not taken into account in optimization of the BBC method. However the path, although only slightly longer than Path 17, does differ substantially in its nature in having a very unfavourably sited receiving location. As the receiving location correction is only a modest −7.5 dB it can be readily understood why the CCIR method overestimates the field strength.

8.9 Path 18 Crystal Palace to Castleton

For the CCIR method the P:M ratio is in the range 13.5 to 15 dB whereas for the BBC method the prediction accuracy is good. Here again no s.v.f. value is available and the path was not taken into account in optimization. The path does not appear to to be one likely to result in unduly high diffraction losses in relation to its length and so it is not clear why the CCIR method should overestimate the field by so much unless there was some obstruction near the receiver.

8.10 Path 30 Sutton Coldfield to Kingswood

For the CCIR method the P:M ratio is in the range 5.5 dB (1% time) to 16.5 dB (10% time) and for the BBC method 12 dB (1% time) and 17.5 dB (5% time). The Kingswood site, although high, suffers substantial clutter losses due to trees, as indicated by an s.v.f of −5.5 dB and an assumed clutter loss of 16 dB for the BBC method optimization. Thus in this case local clutter effects, which are not fully taken into account by either prediction method, account for much of the discrepancy. One particular feature of these results is the unusually large fading range of the received signal in relation to the predicted range by either method.

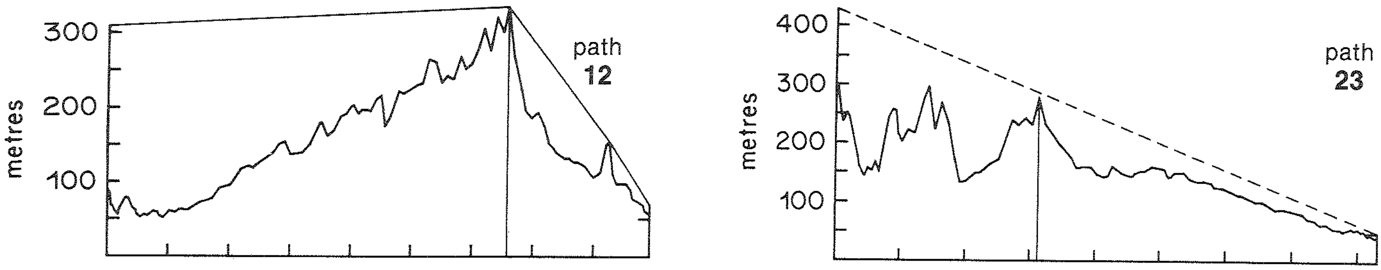
The above paths were all found to have large positive ratios of P:M. The following demonstrate the reverse and are illustrated in Fig. 2.

8.11 Path 12 Crystal Palace to Oxford

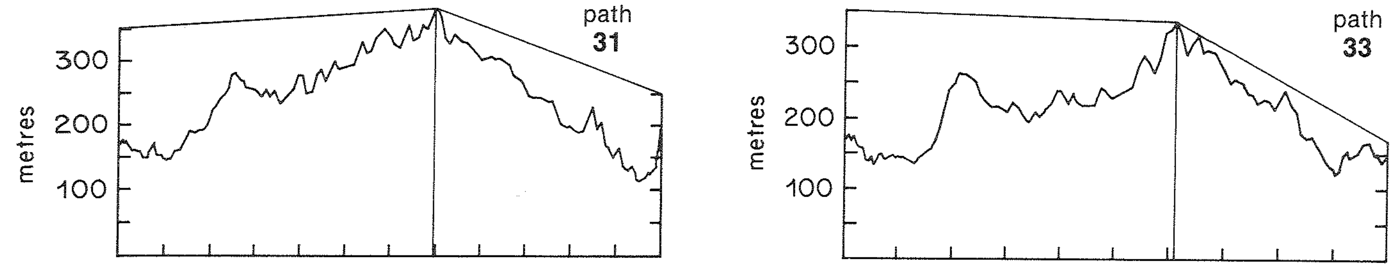
For the CCIR method the P:M ratio is in the range −14.5 to −21 dB whereas for the BBC method it is in the range −12 to −14 dB. No s.v.f value is available, but for the BBC method optimization there was assumed to be no clutter loss, implying an exceptionally open site. The path profile gives no reason to suppose that field strengths would be unduly high by comparison with, say, that of Path 16 which yielded unexpectedly low fields.

8.12 Path 23 Pontop Pike to Dishforth

For the CCIR method the P:M ratio is in the range −15 to −16 dB and for the BBC method in the range −5 to −12.5 dB. However the measured s.v.f was +10 dB and the assumed clutter loss for BBC method optimization was 3 dB, as compared with the predicted value of 15 dB. Application of these factors significantly reduces any discrepancies. The profile shows the path to be 'line-of-sight'.



Crystal Palace to Oxford path length 90km **Pontop Pike to Dishforth** path length 83km



Sutton Coldfield to Green Hailey path length 121km **Sutton Coldfield to Mursley** path length 100km

Fig. 2 - Paths having a high negative value of Prediction : Measurement.

8.13 Path 31 Sutton Coldfield to Green Hailey

For the CCIR method the P:M ratio is in the range −14 to −24.5 dB and for the BBC method from −6 to −30 dB. No s.v.f. value is available and the clutter loss assumed in BBC method optimisation is 4 dB, as compared with the predicted value of 11.5 dB. As the path profile is not greatly dissimilar to that of Path 16 (and indeed the BBC method predictions for these paths give very similar results) it is extremely difficult to account for the fact that the measured values differ by more than 30 dB for all time percentages.

8.14 Path 33 Sutton Coldfield to Mursley

For the CCIR method the P:M ratio is in the range −11 to −13 dB whereas that for the BBC method was in the range −3.5 to −6.5 dB (with zero clutter loss assumed in optimization). However the measured s.v.f. indicated a correction some 7 dB greater than derived from the receiving angle (and would thus lead to a corresponding lessening of the negative P:M ratio). Hence for this path any discrepancies can be accounted for.

9. GENERAL COMPARISON BETWEEN PREDICTION ACCURACY OF CCIR AND BBC PREDICTION METHODS

Figs. 3(a) to 3(c) are derived from Tables 6 - 11 and indicate the correlations between predictions by the two methods over individual paths for 1%, 5%, and 50% time conditions. Various features may be noted:

i) The largest Prediction : Measurement ratios are positive and common to both methods. The paths giving rise to these large overpredictions are amongst those discussed above.

ii) There are, for 1% and 5% time, very few points in the top left quadrant (BBC method predicting high and CCIR method predicting low).

iii) For 1% time, virtually the only points in the bottom right quadrant (CCIR method predicting high and BBC method predicting low) are mixed paths.

iv) Although there may be a tendency for the points to be clustered closer to the abscissa axis than to the ordinate (indicating greater accuracy for the BBC method) for 5% and 50% times, this trend is absent at the 1% time.

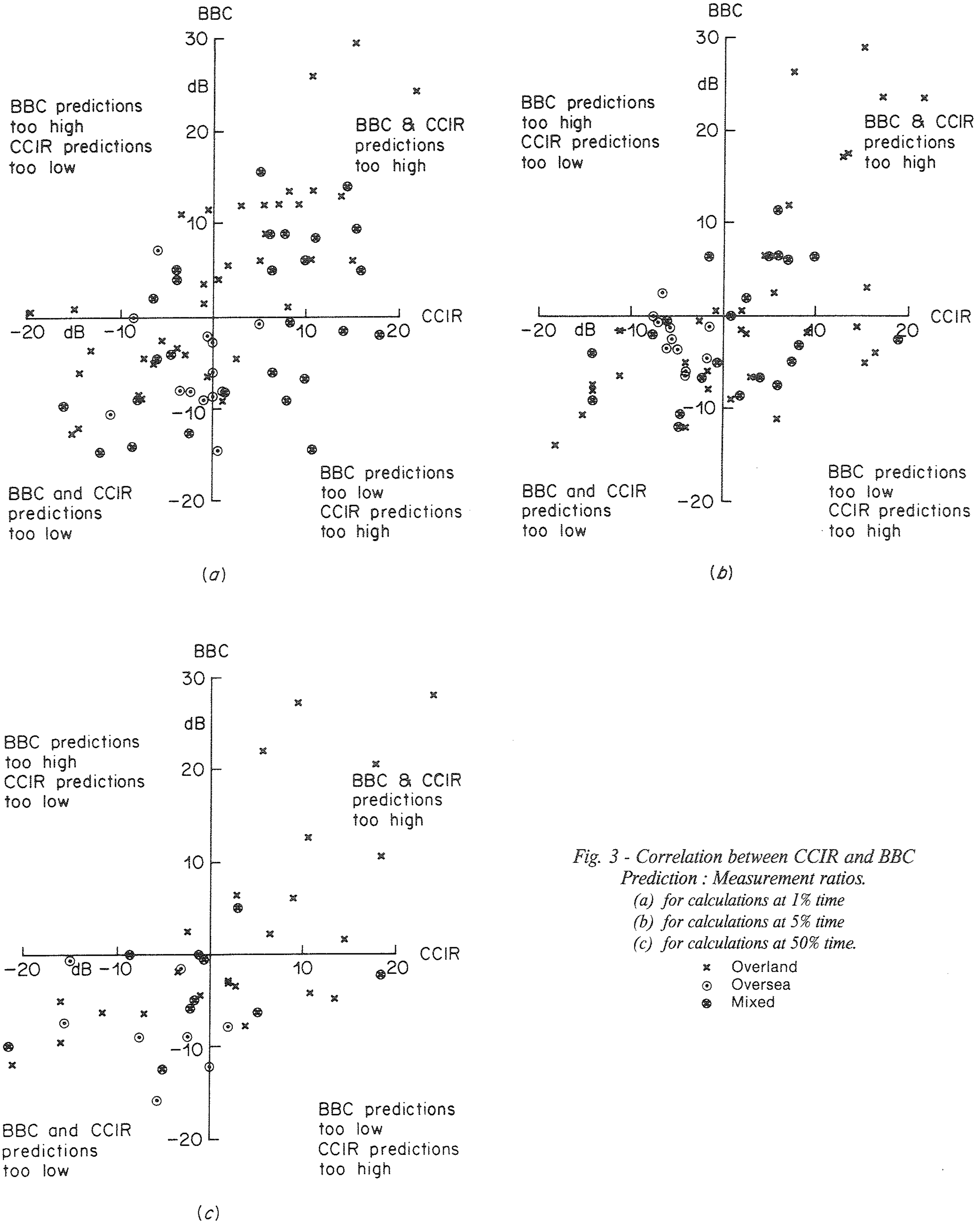


Fig. 3 - Correlation between CCIR and BBC Prediction : Measurement ratios.
(a) for calculations at 1% time
(b) for calculations at 5% time
(c) for calculations at 50% time.

× Overland
⊙ Oversea
⊛ Mixed

10. PATH LENGTH DEPENDENCE OF RATIO PREDICTION : MEASUREMENT

Figs. 4 and 5 indicate the relationship between P:M ratio and path length for predictions by CCIR and BBC methods respectively. There does not appear to be any significant distance-dependence at 1% time.

Whilst it may be considered that the accuracy of prediction increases with increasing path length for 5% and 50% times, this is probably only because the number of samples at the greater distances are small, and these results have been used in optimizations of both methods.

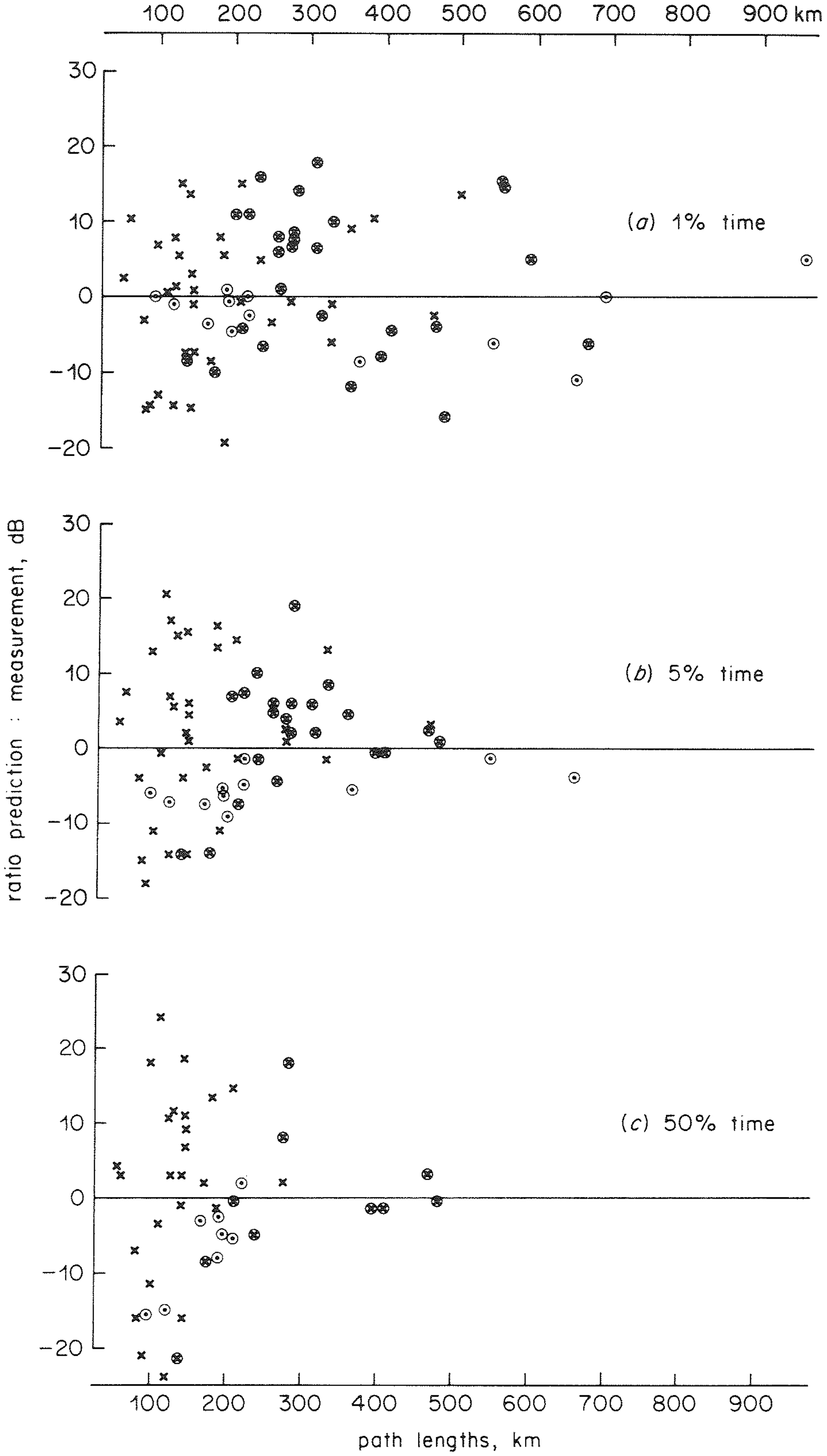


Fig. 4 - Ratio Prediction : Measurement as function of path length for CCIR method without Δh correction.

× Overland
⊙ Oversea
⊛ Mixed

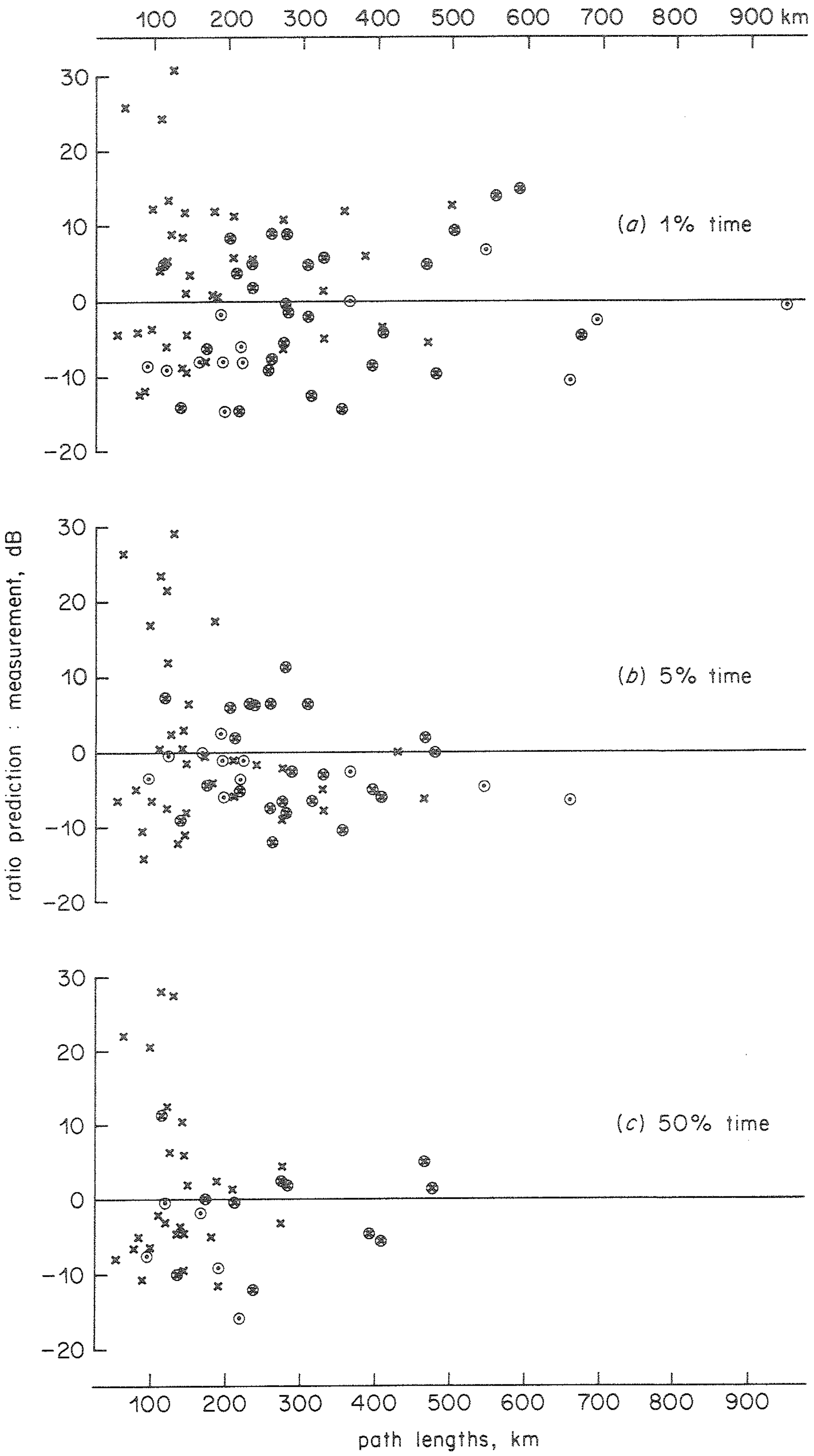


Fig. 5 - Ratio Prediction : Measurement as function of path length for BBC method.

× Overland
⊙ Oversea
⊛ Mixed

11. FREQUENCY DEPENDENCE OF FIELD STRENGTH WITHIN THE UHF BAND

As already mentioned, long-term measurements have been made on two UHF frequencies over some of the paths discussed here. In such cases the results quoted in Tables 3 - 5 are average values. It is nevertheless of interest to establish whether any obvious frequency dependency exists, although any comparisons must be teated with much caution if not carried out simultaneously. Table 12 attempts to provide a summary of such results, virtually all being obtained over different time periods apart from some overlapping in the case of Paths 45 - 49 (as discussed below).

No obvious frequency dependence is deducible from Table 12 although there may be a trend at 1% time, and to a lesser extent at 5% time, for the higher frequency to give higher field strengths over short paths and lower fields over long paths.

The BBC did, however, carry out simultaneous recordings over Paths 45 to 49 on 560 and 774 MHz for a period of nine months[7]. The results indicated that at the 1%, 5%, and 10%, time levels, the field strengths at the higher frequency exceeded those at the lower by between 0 and 8 dB. At the 50% time level the higher frequency gave a slightly lower field strength over the two (shortest) paths for which signal was recorded for this time percentage. It was deduced that it was probably not worth trying to take this frequency dependence into account in planning.

For Paths 46, 47 and 49 the comparative results of these simultaneous measurements are in direct conflict with those in Table 12 in that the simultaneous measurements show the higher frequency to provide higher or comparable field strengths. Apart from supporting the conclusion that no frequency dependence should be taken into account, this discrepancy has even more serious implications. It would appear that over such paths the reliability of the field strengths exceeded for the small time percentages relevant to interference planning may not be guaranteed to within less than about 10 dB even if based on recording periods of about two years duration. The consequences for any prospect of improving prediction accuracy are self-evident.

Table 12: Comparison of measurements in Bands IV and V

Path type	Path No.	Equivalent TV Channel no.	Field Strength on higher freq. rel. to that on lower (dB) for specified time %			Path length (km)
			1%	5%	50%	
Land	13	34 & 44	+5	−1	−3.5	51
"	22	32 58	+1.5	+4		465
"	26	32 59	+5.5	+4		210
"	28	32 59	−6	−4	−2	330
"	29	32 59	−5.5			411
"	31	24 36	+10	+10.5	+3	120
Sea	45	32 59	+6	+6	−1	198
"	46	32 59	−5.5	−7		365
"	47	32 59	−11.5	−8		543
"	48	32 59				696
"	49	32 59	−13			954

12. DISCUSSION

Results of measurements at UHF over 78 long-and medium-distance propagation paths have been compared to predictions for these paths by prediction methods developed by the CCIR and BBC.

It is apparent that the discrepancy between measurements and predictions as measured by the standard deviations of prediction : measurement ratios is similar for both methods. Superficially, this may seem somewhat surprising as the CCIR method is based on fairly simple statistical principles and takes no account of individual features of the propagation path except close to the receiving terminal.

However it is also apparent that the 'errors' of the two prediction methods are well correlated in cases where these are large. This implies that in such cases there are factors which neither method can adequately take into account. The most significant such factor (other than that of unreliable measurements*), in cases where the prediction overestimates the field strength, is the existence of particular obstacles such as building and trees close to the receiving terminal. In the examination of individual paths forming Section 8 this is found to explain some of the discrepancies.

This introduces the problem common to all such propagation experiments, namely, how to relate measurements at a particular receiving location to the more general case. Clearly the correction applied has to be related to to the precision expected of the prediction method. At one extreme is the basic method of CCIR Rec. 370 (excluding the receiver location correction). Here the correction is required to relate the measurements to 'typical receiving locations'. In this case the correction should try to normalize for both clutter and terrain effects, and this is the aim of conventional 'site variation factor measurements'. However for both the CCIR method incorporating the receiving terrain location correction and the BBC method, the prediction attempts to take account of the terrain effects and hence any correction needs to take account only of local clutter. In such cases normal s.v.f. corrections may not be appropriate unless taken with this aim in mind.

In the limit, were it possible to develop a prediction method which attempted to take full account of clutter losses over individual paths it would, of course, not be necessary to apply any form of correction to the measurements at individual receiving locations. However it seems unlikely that any such method could be developed bearing in mind that losses due to a single tree can easily exceed 15 dB. Comparisons between predictions and measurements would doubtless have been greatly improved had it been possible to ensure that all receiving sites for such tests were either clear of local clutter or otherwise truly representative. However site choice will always be determined by practical considerations.

The comparisons, discussed in Section 11 between measurements made over the same paths at different frequencies and time periods also give cause for concern as to the possibility of ever making a worthwhile improvement to prediction accuracy. Large differences between field strengths exceeded for specified time percentages appear to occur over different time periods even when these periods are of about two years.

13. CONCLUSIONS

An examination of available measurement data at UHF over medium- and long-distance propagation paths has been carried out and the results compared with predictions using the CCIR and BBC prediction methods. It is recognized that almost all these measurement data are those originally used in optimization of the parameters of the BBC method. This is also the case for the CCIR method in respect of the longer oversea paths.

It is concluded that:

i) Both prediction methods appear, overall, to have generally similar accuracies. A small trend for reduced standard deviation for the BBC method may well be accounted for by the fact that this is a biased sample for the reason given above. Some of the largest discrepancies indicated by the BBC method are for some of the few paths not used in the optimization, but excluded deliberately because of doubts about the validity of the measurements.

ii) Those cases having the largest discrepancies between measurements and predictions are common to both prediction methods, indicating the presence of some factor which neither method takes into account.

iii) In some such cases the discrepancy can be accounted for by particular features of the receiving location but in other cases it cannot. There is at least one example where two propagation paths have very similar path profiles and predicted field strengths but for which there is a difference in excess of 30 dB in measured field strengths.

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* Although most of the measurements detailed in this Report were used in the optimization of the BBC prediction method, some of the paths giving the highest prediction errors (e.g. Paths 14 and 16) were excluded from the optimization although the results were available at that time. The reason for exclusion must, presumably, be because of doubt about their validity. Certain other results (e.g. for Paths 17 and 18) were similarly excluded, although known, but in these cases the 'error' of the BBC prediction is small although that of the CCIR method is high.

iv) There is no evidence that application of the 'Δh correction' improves the accuracy of the CCIR prediction, even though in the case of the overland paths such application does reduce the mean error of prediction.

v) For mixed land/sea paths the CCIR method tends to underestimate field strengths received at coastal sites, but to overestimate them at inland sites. The former is consistent with the intention that the CCIR oversea curves should represent field strengths in coastal towns. However this raises the question as to whether the CCIR is being consistent in that no similar rural/urban allowance is made in the case of long overland paths. (NB: The curves for short paths are derived from coverage surveys and may be assumed to be representative of 'town' rather than 'rural' conditions.)

vi) There appears to be no obvious trend for prediction accuracy to vary with path length, although of course it has to be recognized that the statistical validity of the measurements will decrease with increased path length since this increases the temporal variation.

vii) Evidence of frequency variability within the UHF broadcast band is conflicting. Of particular concern is evidence from certain oversea paths for which the apparent frequency trend observed over two extended but consecutive periods is in complete conflict with the trend observed over the same paths during a period of simultaneous recordings. Bearing in mind that the durations of these consecutive measurements were amongst the longest of those examined here, this raises the question of whether uncertainty about temporal statistics represents the real limit to possible improvement in prediction accuracy of field strengths occurring for small percentages of time.

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